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1. Your reference	PDC/DLC/24121 GB	
2. Patent appl *(The Patent C*	0201517.0	Not yet known — 23 JAN 2002
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	m-spatial Limited St John's Innovation Centre Cowley Road Cambridge CB4 0WS	
Patents ADP number *(if you know it)*	8309445001	
If the applicant is a corporate body, give the country/state of its incorporation		
4. Title of the invention	Method of providing a graphical schematic of a location, determining the location of a device, and searching a database.	
5. Name of your agent *(if you have one)*		
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Mathys & Squire 100 Gray's Inn Road London WC1X 8AL	
Patents ADP number *(if you know it)*	1081001	

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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*

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Description	83
Claim(s)	11
Abstract	1
Drawing(s)	10 + 10 Rr

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Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
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11. I/We request the grant of a patent on the basis of this application.

Signature Mathys & Squire

MATHYS & SQUIRE

Date 23 January 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

COZENS; Paul Dennis 020 7830 0000

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METHOD OF PROVIDING A GRAPHICAL SCHEMATIC OF A LOCATION, DETERMINING THE LOCATION OF A DEVICE, AND SEARCHING A DATABASE

The invention relates, in various aspects, to a method of providing a graphical schematic of a location. The schematic may be provided to give a user information on that particular area, or to provide directions to the user. The schematics may be delivered to a fixed or mobile device. Other aspects of the invention relate to a method of determining the location of a device, and a method of searching a database.

In a first aspect the invention provides a method of providing a graphical schematic of a location, the method comprising the steps of:
selecting one or more of points of interest from a database in accordance with a predetermined selection algorithm;
generating a graphical schematic including the selected points of interest; and
outputting the graphical schematic.

The selection algorithm enables a relatively 'uncluttered' schematic to be generated, in which only relevant points of interest (herein referred to as POIs) are provided, and other redundant information is omitted.

Preferably the algorithm includes the steps of:
ranking a plurality of points of interest; and
selecting one or more of the points of interest in accordance with their rank.
Thus for example the algorithm may select only a predetermined number of points of interest, for instance the ten highest ranked points of interest.

Preferably the algorithm includes the steps of:
retrieving one or more stored parameters associated with each point of interest; and

selecting one or more of the points of interest in accordance with their associated stored parameter(s). Thus for instance the parameter may indicate the category of the POI (for instance the POI may be categorised as a 'Cinema' or a 'House'). In this case the algorithm may only select POIs within a certain category, or may preferentially select POIs within that category.

Preferably the selection algorithm comprises the steps of:
selecting a location; and
selecting one or more points of interest within a predetermined radius of the selected location. Thus the algorithm limits the field of selection.

In one example the database includes a plurality of nodes and the selection algorithm includes the step of:
selecting a node;
defining a region surrounding the node; and
selecting points of interest within the defined region. Thus the node may represent, for instance, a junction in a road map.

The region may have a complex shape, or may simply be a circular region centred on the node.

In a further aspect the invention provides a method of providing a graphical schematic of a location, the method comprising the steps of:
calculating a direction;
generating a graphic schematic including information which indicates the calculated direction; and
outputting the graphical route schematic.

In contrast with a conventional 'map', which may include an arrow indicating the direction north, this aspect of the invention enables the graphic schematic to be 'customised' by indicating any desired direction - for instance to indicate the

direction in which a user should move in order to proceed to a desired destination.

The information may be presented in a variety of ways. For example the schematic may be coloured red in the desired direction, and blue away from the desired direction, with gradations of colouring inbetween. Preferably the information is provided in the form of a marker such as an arrow.

In a further aspect the invention provides a method of providing a graphical schematic of a location, the method comprising the steps of:

determining the current position of the moon or sun;

generating a graphical schematic of the location, the schematic including information which indicates the current position of the moon or sun; and

outputting the schematic.

This aspect enables a user to orient themselves more easily by noting the current position of the moon or sun, and correlating this with the information provided in the schematic.

Again, the information may be provided in a variety of ways. For instance the schematic may be coloured more brightly in the direction of the moon or sun. Alternatively the information may comprise a marker. In one example the position of the marker within the schematic is dependent on the current position of the moon or sun. In another example the marker may comprise a shadow image, the configuration of the shadow image being dependent on the current position of the moon or sun.

In a further aspect the invention provides a method of providing graphical schematic data, the method comprising the steps of:

receiving configuration data;

generating a graphical schematic in accordance with the configuration data; and

outputting the graphical schematic.

This aspect enables a graphic schematic to be 'customised' in any desired manner, for instance to adapt to different device properties (such as screen size or resolution) or user preferences.

In a further aspect the invention provides a method of providing graphical schematic data, the method comprising the steps of:
storing a list of location identifiers;
selecting one of the stored location identifiers;
generating a graphical schematic associated with the selected location identifier; and
outputting the graphical schematic.

This aspect of the invention enables a list of 'favourite' locations to be stored and selected. This provides a quick and simple method of specifying the location to be displayed in the graphic schematic.

Preferably the method further comprises the step of updating the list of location identifiers, for instance by way of deletion, addition or amendment.

Preferably the graphical schematic is output to a device, and the method further comprises the steps of:
receiving a selection request from the device; and
selecting the location identifier from the list in accordance with the selection request. Thus the selection may be made by a user, typically from a mobile device. The list may be stored at the device or in a central store.

In a further aspect the invention provides a method of providing graphical schematic data, the method comprising the steps of:

a) providing a first schematic, the first schematic comprising graphical data associated with a specified region; and

b) after step a), providing one or more one or more routing schematics, the routing schematic(s) indicating a route from a first location to a second location.

In one example the first schematic comprises an orientation schematic and the specified region includes the first location.

In a second example said first schematic is a location schematic and the specified region includes the second location.

In a third example the first schematic comprises an overview schematic and the specified region includes both the first and second locations.

Typically the first schematic and/or the routing schematic(s) are generated by a method according to any of the preceding aspects of the invention.

In a further aspect the invention provides a method of providing a graphical schematic, the method comprising the steps of:
obtaining first source data from a first data source;
obtaining second source data from a second data source;
generating a graphical schematic including said first source data and said second source data; and
outputting said graphical schematic.

This aspect 'merges' or 'conflates' data from different sources in order to generate the schematic.

Preferably the method includes the steps of:
identifying a first feature in the first data source;
identifying a second feature in the second data source;

determining whether the second feature overlaps with the first feature; and associating the second feature with the first feature if the second feature overlaps with the first feature. This enables the data from the two sources to be merged smoothly. Thus for example the first feature may be a building, and the second feature may be a name associated with that building.

In a further aspect the invention provides a method of providing a graphical schematic of a location, the method comprising the steps of:
retrieving graphical data from a database;
generating a schematic by modifying the graphical data in accordance with a predetermined modification algorithm; and
outputting the schematic.

This aspect enables a schematic to be customised for instance by aligning the graphical data with a selected screen geometry. Alternatively the schematic may be simplified for instance by straightening lines. Alternatively the 'look and feel' of the schematic may be customised, for instance by shading areas according to crime statistics.

In a further aspect the invention provides a method of providing route information, the method comprising outputting a plurality of route schematics which together provide an ordered sequence of directions from a first location to a second location.

This aspect enables a sequence of schematics to be presented (either in graphic, textual or vocal form) which guide a user between the first and second locations. The schematics may be output in sequence order, or may be output out of sequence order. If the schematics are output out of sequence order, then information will need to be output separately which indicates the correct sequence order required.

In most cases the first and second locations will be different locations. However in some cases the first and second locations may be the same. For instance the route may be a circular route for guiding a user past a number of tourist attractions or scenic buildings.

Typically the method further includes the step of selecting a route between the first and second locations. The route may be selected in accordance with a user preference (for instance selecting a route which is safe, or which passes a large number of tourist attractions or scenic buildings).

Preferably the method further comprises receiving a routing request, for instance from a user device or from a Location Based Service (LBS), including the first location and the second location.

Preferably the method further comprises receiving one or more route update requests; wherein at least one of the route schematics is a route update schematic which is transmitted in response to a respective route update request.

Preferably each routing update request is received from a user device; and each route update schematic is transmitted to said user device.

The route update requests may be generated automatically, for instance by performing a network fix to monitor the current location of a mobile device, wherein the or at least one of the schematics is transmitted in response to a change in the monitored location of the mobile device. Alternatively the route update requests may be generated in response to a user input.

Preferably the method further comprises the steps of:
selecting a sequence of said nodes which define a route between the first location and the second location; and
compiling a route schematic for each selected node.

Preferably at least one of the route schematics, typically the first schematic in the sequence, comprises a summary schematic giving an overview of directions from the first location to the second location.

Preferably the schematic is output to a hand-held device.

In a further aspect the invention provides a method of determining the location of a device, the device including a user input device and a transmitter, the method comprising the steps of:
receiving a location identifier from the user input device;
transmitting the location identifier from the transmitter to a server;
receiving the location identifier at the server; and
determining the location of the device at least partially on the basis of the received location identifier.

This aspect of the invention provides a 'manual' method of determining the location of a handset, in contrast to conventional 'automatic' methods.

Preferably the device is a hand-held device.

Preferably the method further comprises the step of performing a network fix on the device, and determining the location of the device on the basis of the network fix and the received location identifier.

Preferably the method further comprises the steps of:
transmitting a plurality of possible locations to the device;
presenting the possible locations to the user;
receiving a location selector from the user input device, the location selector identifying one of the possible locations;
transmitting the location selector from the transmitter to a server;

receiving the location selector at the server; and
determining the location of the device on the basis of the received location selector. Thus the amount of user input required is minimised.

In one example the location identifier comprises a sequence of one or more letters, and the method further comprises selecting a plurality of possible locations each including the sequence of one or more letters. In another example the location identifier comprises a location category, and the method further comprises selecting a plurality of possible locations each falling within the location category. These are particularly convenient methods of prompting user input.

The possible locations may be presented to the user in graphical form and/or in textual form.

In a further aspect the invention provides a method of searching a database, the method comprising the steps of:
a) searching the database to identify a number of database entries each including a sequence of X letters;
b) determining whether the number of database entries identified in step a) exceeds a predetermined maximum;
c) if the number of database entries identified in step a) is less than or equal to a predetermined maximum, then
d) transmitting the value X to a user input device,
e) receiving a sequence of X letters from the user; and
f) searching the database to select one or more database entries each including the input sequence of X letters; and
g) if the number of database entries identified in the step a) is greater than the predetermined maximum, then repeating steps a) and b) with a greater value for X.

This aspect provides an 'X-letter' search mechanism which can be customised to suit a particular screen size (by varying the maximum number of database entries permitted).

In a further aspect the invention provides apparatus including features for performing the method steps described above in any aspect of the invention. Typically the apparatus is in the form of an appropriately programmed computer. In a preferred example the apparatus is in the form a server remotely located from a user, where the user may be a Location Based Service (LBS) and/or a mobile device. The mobile device (typically a hand-held device) is appropriately programmed to receive and present schematics (typically in graphical form) to a user.

In a further aspect the invention provides a computer medium carrying a computer program for performing the method steps described above in any aspect of the invention.

In a further aspect the invention provides a computer program for performing the method steps described above in any aspect of the invention.

Different features of the various aspects of the invention may be combined in any appropriate order.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

Figures 1-12, 22 and 23 are a series of exemplary screenshots;
Figure 13 is a schematic drawing of the basic system hardware;
Figure 14 is a flow diagram illustrating a preferred method of performing a location-fix;
Figure 15 is a view of a set of route edges associated with a route;

Figure 16 shows a geometrically simplified version of Figure 15, including four sectors associated with one of the junctions;

Figure 17 is a schematic drawing of the software architecture;

Figure 18 is a view of a network;

Figure 19 illustrates a data set resulting from a growing algorithm performed on the network of Figure 18;

Figure 20 illustrates segmentation of the data set of Figure 19; and

Figure 21 illustrates components of a system for adding an entry to a MyPlaces list .

A basic system hardware architecture is shown in Figure 13. A location/guidance server 1 is connected to a database 2 and communication network 3. The communication network 3 communicates with a mobile device 4 via a wireless link.

The location/guidance server 1 comprises software modules for location identification and for the generation of routing information such as route schematics as well as interfaces to users of the location/guidance server and to database 2.

The information provided by the server 1 is generally in the form of *schematics*. In some cases the schematics may be non-graphical: for instance in the form of textual or voice data. However in most cases the schematics include graphical information in the form of simplified maps, and are derived from conventional mapping and geographical data. The schematics include only such information as is useful and necessary for a routing task, or other task.

Database 2 contains geographical information used by location/guidance server 1 in the identification of locations and generation of routing information. The geographical information includes information on roads, road names and classifications, buildings and building classifications, business names and

business classifications, full address data and other geographical and mapping features. In some embodiments, database 2 comprises a single homogeneous database. In the preferred embodiment, database 2 comprises several heterogeneous data sources, such as databases and files.

Mobile device 4 is typically a hand-held device such a mobile phone or personal digital assistant (PDA). The mobile device 4 may have a significantly smaller screen, lower data transfer rate and more limited user interface than is found in equivalent browser/hardware arrangements for the fixed Internet. Two different classes of mobile device are considered here (though in other embodiments, different kinds of devices may be used): small devices and medium devices.

Small and medium devices differ in certain characteristics, including screen resolutions, colour / monochrome displays and user interaction methods. For example, smaller devices such as WAP-enabled mobile telephones (one example being the Siemens S45 mobile phone) would typically have small, monochrome displays, using standard mobile telephone keys and WAP menus for user interaction. Medium size devices may have slightly larger screen resolutions (typically no less than 120 x 120 pixels) and may have colour displays. An example of such a device is the Trium Eclipse mobile phone. As will be seen, the information generated for small and medium devices is generally different and takes into account the different characteristics of the devices.

The approach taken for medium size devices is also applicable to larger devices such as the Compaq Ipaq™ or Nokia™9210, which typically have larger resolution colour displays and use a point-and-click interface, which may be operated using a stylus. Therefore, "medium devices" shall be taken to include such devices. In fact, techniques described for small and medium devices may be applied to devices of any size. Furthermore, according to user preference,

schematics described below for medium devices can be used on small devices, particularly if limited to a view of a single junction.

The device 4 may be a General Packet Radio Service (GPRS) device.

A Location Based Service (LBS) – also known as a Location Based Application or Location Enabled Application - is run on a second server 10 which is also connected to the communication network 3. The LBS is an application which uses the location/guidance services of server 1 as part of a larger application. Many examples of such applications may be imagined – one such example might be a restaurant guide which provides a user with information regarding a restaurant close to his present location, including reviews of and directions to the restaurant.

Although in a preferred embodiment, services are offered for use by LBSs, in some embodiments location/guidance server 1 may provide services, for example a complete location and routing service, directly to the mobile device via communication network 3.

The location/guidance server 1, in combination with database 2, provides a locating, routing and guidance 'web service' accessible through Internet-like protocols to the LBS running on server 10. The web service provides an API to LBS developers.

The structure of the software that provides this web service will now be described in more detail with reference to Figure 17. The location/guidance technology includes a number of layers, including:

- Web service interface 40 provides the API and infrastructure to allow the LBS to access the location/guidance technology and to allow the location/guidance technology to manage multiple users for the LBS.

- The service modules 42 are software modules which provide various aspects of the location/guidance services, including identifying locations and generating schematics.
- The feature model 44 is a data model which supports the service modules.
- The feature store 46 is a mechanism for overall management of data, providing a single common interface to all data regardless of the source from which it is drawn.
- The connectors 48 are interface modules which allow data stored on disk in different formats to be accessed efficiently and presented to the higher parts of the system through a common interface at the feature store level.
- Data sources 50 are files and/or databases on disk, either in third party formats where databases have been supplied by third parties, or in proprietary formats.

For example, referring back to Figure 13, following interaction between LBS server 10 and mobile device 4, LBS server 10 makes a routing request to guidance server 1. Referring now to Figure 17, this request is received by web service interface 40, which invokes the appropriate one (or possibly several) of service modules 42. The invoked module then requests any required data from feature store 46 using feature model 44. Feature store 46 identifies the source(s) of the required data, and fetches the data from one or more of data sources 50 using the appropriate connector(s) 48.

Generally speaking, the location/guidance server 1 provides the following services which are implemented by service modules 42:

- Identifying a mobile device user's present location
- Identifying a user's desired destination
- Generating routing information for routing the user from his present location to his desired destination.

Individual Location Based Services may use only aspects of the services provided. For example, LBS server 10 may request routing information only, providing starting and finishing locations as parameters of the request.

Alternatively, these services may be combined to provide a complete location and guidance service incorporating the three steps of identifying the device's present location, identifying a desired location and providing routing information between the two. The location and guidance technology will now be described in terms of such a complete service with reference to the remaining Figures.

The screen shots of Figures 1 to 12 are examples of what may be displayed by the mobile device 4 in an exemplary implementation. Other implementations are possible. Specifically, user interaction may be implemented in a different manner from that suggested in the screen shots depending on the type of mobile device used. Furthermore, the user interaction aspects may depend on the nature of the LBS using the location/guidance services, and on the nature of that use.

For instance, the screen shots of Figures 1-12 employ icons which are appropriate for devices with point/click style interfaces. It will be appreciated that hyperlinks or action keys may be used instead, or any other means appropriate to the particular device being used.

Referring to the main menu shown in Figure 1, the user is presented with three options:

- Where are you?
- Destination?
- Directions

In the example of Figure 1, the user has already specified his current location as the "Red Bull" pub and his required destination as the "Six Bells" pub.

The three options will be described separately below.

Where are you?

If the user selects the 'Where are you?" option then a location-fix is carried out as described below.

Several automatic and manual methods of performing a location-fix on the device 4, as well as combinations thereof, may be provided. Automatic and combined methods depend on the ability of the device 4 or the communication network 3 to identify the device's location to within a certain level of accuracy. This is referred to as a network location fix and may be of low, medium or high accuracy. The network location fix may be implemented continuously, at regular intervals, or on request.

Instead of using network 3 to perform the network fix, some other network (not shown) may be used.

Various different types of network fix will be described below, and categorised as 'high', 'medium' or 'low' accuracy,

In an example of a high accuracy system the device 4 incorporates a Global Positioning System (GPS) unit which can fix the location of the unit to an accuracy of 5-10m.

In an example of a medium accuracy system the device 4 incorporates an enhanced observed time difference (EOTD) system designed to implement the FCC E-911 provisions, and can fix location to an accuracy of 50-300m.

In an example of a low accuracy system the communication network 3 comprises a cellular network which can fix the location of the device 4 to within an accuracy of up to ca. 250 metres in urban areas (the accuracy may fall to as low as 5-10 km in rural areas) based on the current cell in which the device 4 is registered.

Referring to Figure 14, in a first step the server 1 determines whether a high or medium accuracy location fix is available. If so, a network location fix is first used to identify the device's location within a certain accuracy.

Where no network fix is available, or only a low accuracy fix is available, a manual location fix is used. Generally speaking, the manual location fix is obtained through a dialogue with the user, in which the user is prompted to supply information relating to his present location. An example of such a procedure is illustrated in Figure 14, and associated screen shots are shown in Figures 2-6.

In the second step of Figure 14, a pick list of categories is displayed. An exemplary pick list is shown in Figure 2, including, for example, the option to search by shop name or road name and house number. In other examples, the first three menu options may be replaced by a single "Business name" option. Selecting one of these options takes the user to a search screen such as one of those shown in Figures 3, 5 and 6.

The search screen asks the user to enter at least the first "X" letters of the name of a road, business or the like (depending on the selected search option). It may also request further information, such as the house number. In this example, three letters are requested. Generally, the value "X" is calculated dynamically by the following method.

In a first step, an approximate bounding area is determined to reduce the number of features that need to be considered. All subsequent searching only deals with features within this bounding area. In a preferred embodiment, the bounding area is given by a low accuracy network location fix, for instance the area of the cell in which the device 4 is currently registered. If no network location fix is available, then the bounding area is determined by requesting the user to input a specified area, for instance a town or part of a city. This would occur before the search screen is displayed.

In a second step, the algorithm determines the value "X": a minimum number of characters required such that a "reasonable number" of matches will be found. The "reasonable number" is determined in accordance with the size and resolution of the screen of the device 4, and is selected such that a list of possible matches can be presented on (at most) one or two screens of text on the device 4. "X" is calculated as follows:

- Starting with prefix size 1, for each possible prefix of that size occurring in the relevant data within the bounding area, the number of occurrences of that prefix in the data is calculated. The relevant data comprises those features to which the search relates depending on the search option chosen by the user, for example the names of shops or roads. The prefix with the highest number of occurrences is then determined.

- While the highest number of occurrences for a prefix of the given size exceeds the "reasonable number" (as determined in accordance with screen size) the prefix size is increased and the above calculation is repeated.

Since junction searches use multiple road names, "X" is likely to be lower than it would be for a simple road name search. This is because only specific pairs of road names are involved, based on the known junctions in the specified area.

A search screen is then generated requesting that the user enter at least "X" letters and is transmitted to the device. The user enters a string of letters which are transmitted to the server, where the relevant data within the bounding area is searched for matches. The matches are presented to the user for further selection. Multiple selection screens are provided if the number of matches exceeds the number that can be displayed on a single screen. In one example, the user is presented with a single list split over several pages with a "next page" option. In another example, the list is broken into a hierarchy of related sub-lists. This may occur where the matches cannot be conveniently displayed on a few screens, for example, if the user enters fewer than the requested X letters. It allows the user to quickly "drill down" to the desired entry rather than page through to the entry.

As an example, the list may be broken down into a hierarchy of alphabetically ordered sub-groups. For example, a first series of items is presented:

1. All Bar One - Devonshire Arms
2. Duke of Argyll - Fox and Hounds

Etc.

If the user selects group 1, then they are presented with a list of sub-groups such as:

1.1 All Bar One - Bombadier
1.2 Cambridge Blue - Clarendon Arms
Etc.

The user then selects one of the sub-groups until all of the items in the sub-group can fit on the screen. The menu hierarchy (depth and options displayed) is

thus determined on the basis of the device's screen size - smaller devices get deeper sets of menus.

An example of a location search is described below with reference to Figures 3 to 6.

In Figure 3, the user is asked to enter at least three letters of the name of a bar or pub. If there is an exact match and the three letters entered unambiguously identify a specific bar or pub, that bar or pub will be selected as the user's present location and the user will be returned to the screen of Figure 1. If not, a pick list of locations will be displayed, as shown in Figure 4.

In this example, the user enters the letters "GRE" on the screen of Figure 3, which produces three possible matches. These are displayed and may be selected on the screen of Figure 4.

In the examples, starting from Figure 2, if the user selects the "Road Junction" search option, then the user is prompted to enter at least three letters each of two roads in the screen of Figure 5. If the user selects the "No. and Road Name" search option in Figure 2, then the user is prompted to enter a house number and at least the first three letters of the road in the screen of Figure 6.

In alternative methods (not illustrated), the location may be entered by:

- Entering a 'code' identifying the location, which is displayed at a specific location (for example an advertisement in a known place) and copied by the user.

- Electronically communicating information identifying the location from a kiosk or terminal in a known place (for example in a tourist office, hotel or airport) to the device 4, for example by SMS or e-mail.

Referring to Figure 14, if a high accuracy location fix is available, then in some circumstances the network fix may provide sufficient detail to identify the location. In this case, a 'junction view' routing schematic is displayed, as described in more detail below under the "Directions" heading. If the user has already specified their destination (as described in more detail below under the "Destination?" heading) then the 'junction view' routing schematic indicates the direction in which the person is to start moving. The person may then use this to orient themselves.

If more detail is required, or if only a medium accuracy network fix is available, then the algorithm moves to an 'orientation' step. The 'orientation step' is also used where a manual location fix has been made.

In the 'orientation' step, the user is displayed with information showing Points Of Interest (referred to hereinafter as POIs) in the area of uncertainty (as determined by the previous network fix or manual location fix), such as road/footpath junctions, landmarks, key buildings or other points of interest.

In a small device, the user may simply be presented with a textual list of possible locations. The user can then pick one, and get a more detailed graphic orientation schematic showing only that location. The orientation schematic shows the selected location, along with buildings, street furniture or other points of interest. The user is then asked to confirm that he is at that location.

In a medium device, an orientation schematic is displayed first, showing the area of uncertainty, and a number of distinguishable locations.

The orientation schematic covers the entire area of the location-fix. It presents a stylised image based on network data (roads and paths) and POIs.

For instance, the orientation schematic could represent multiple exits from a large building or other structure/area (e.g. office block, tube station, car park). In the case of exits that do not lie at actual road junctions, then a 'virtual junction' (see below) is created at the exit.

All the network elements within the location-fix are identified by a spatial search. Points where network elements meet are associated with new 'simple junctions'. An example of this is shown in Figure 16. Figure 16 shows a collection of network elements (for instance roads or paths) 20-26 connected by nodes 27,28. The nodes 27,28 are identified as 'simple junctions'.

The underlying network data (for example that supplied by TeleAtlas) allows network elements to be classified as being 'part of junction'. Thus, each of the elements 20-26 in Figure 16 is identified as being 'part of a junction'. Thus it is possible to identify zero or more 'extended junctions' within the location-fix area. In order to identify extended junctions, the following algorithm is carried out:

1. Make a set of network elements that are classified as 'part of a junction' and in the location-fix area (for example, elements 20-26).
2. Select a network element from the set and associate it with a new extended junction.
3. Remove the network element from the set.
4. Using the network connectivity at each end of the network element identify network elements that this element is attached to. If any of these are in the set then recurse back to 3.
5. If the set is not empty then go back to 2.
6. Remove simple junctions which are included in extended junctions

The set of junctions for the location-fix area is the combination of simple and extended junctions.

Thus, for example referring to Figure 16, if network element 20 is the first element selected in step 2 above, then the algorithm will define a first extended junction comprising elements 20-23 and a second extended junction comprising elements 24-26.

The stylised network in the orientation schematic is based on the junctions identified above together with those [parts of] 'non-junction' network elements that fall into the location-fix area. These are analysed into 'Paths' and their geometry simplified as described below with reference to Figure 17.

The network elements are first condensed into a set of 'paths', each 'path' being a series of connected route edges sharing the same road name, each forming a simple string of edges. Thus for example in Figure 16, a first 'path' may comprise elements 20,23 and 25, a second 'path' may comprise elements 21 and 22, and a third 'path' may comprise elements 24 and 26.

Each path is then individually simplified. This process involves removing details from, and otherwise manipulating the 2D polyline representation of the path.

For example, road sections that lie within a certain tolerance of being straight are straightened.

Distance tolerance considerations are taken into account as follows. A path is originally defined by a polyline containing a set of co-ordinates specified by the source data. This polyline is simplified by removing co-ordinates whilst maintaining the constraint that the simplified polyline lies within a distance error 'd' from the original polyline. In one example, the value of d is chosen based on the size of the area covered by the orientation schematic. For example, it might be chosen as 1/10th of the maximum extent of the area covered. In

another example, the value of d may change to reflect the size of the individual path. Further enhancements may constrain the error in the direction of the simplified polyline compared to the direction of the original at the corresponding point. This would be an angular constraint similar to but looser than the one applied at significant junctions.

Particular care over angular tolerànce is taken near 'significant junctions' (as defined below), since the relative angular separation of roads at a junction affects the user's confidence.

Geometries are arranged:

- to ensure that the alignment of the features on the screen makes best use of the screen's aspect ratio;
- if the destination has already been chosen, and the orientation schematic is being used as the first step in getting the user moving towards the destination, then the orientation schematic may be oriented to ensure that the user's current direction of movement is oriented up the screen (or alternatively left to right, depending on the screen format);
- If the orientation schematic is being used simply to identify the user's location, then the orientation schematic can either be oriented conventionally (i.e. north at the top), or alternatively, to ensure that some significant feature (e.g. the most important road currently in the orientation schematic) be aligned either up or across the screen.
- to align lines with the horizontal or vertical and to fit the most information into the smallest areas.

An example of simplification of the data of Figure 16 is shown in Figure 17. The first 'path' has been straightened out and aligned up and down the page. Element 24 has been straightened out. The angular separation between elements 23 and 24 at node 27 has been maintained.

If some of the paths are above a threshold length, then a new 'virtual junction' is introduced at their mid-point. Note that this deals with the case of a location-fix area having a single network element running through it but no junctions.

POIs for the orientation schematic are then selected as described below under the heading "Orientation Schematic POI selection".

From an initial orientation schematic, the person selects a junction (or virtual junction) at which they believe they are positioned. Referring to Figure 14, the algorithm then presents a 'junction view' routing schematic as described in more detail below under the "Directions" heading. The person may then use this to orient themselves, or, if they have chosen the wrong starting point, they may return to the initial orientation schematic to choose a different junction.

More sophisticated devices may allow greater flexibility: for instance a point/click device may be used to allow any location within a displayed area to be selected, instead of limiting the selection to one of the displayed distinguishable locations.

If the user has already input their destination (see below under the heading "Destination?") then the orientation schematic may include an arrow indicating the required direction of movement towards the destination.

Destination?

If the user selects the "Destination" option in the menu of Figure 1, then a variety of different methods may be employed to identify a destination.

One scenario is based on a person receiving a message to meet their friends at a particular location. The message refers to the location by name (for example 'The Red Lion') but the name has been tagged with additional information,

specifically the coordinates of the location. These can be easily expressed as Lat/Long coordinates (Latitude & Longitude) in a specified coordinate system (for example WGS84). This is the form of output from most GPS devices. Tagging a name with a geographic reference (or location tag) is essentially the same as associating a hyper-text URL with a piece of text in an HTML page, and easily achieved in a markup language.

Alternatively the location could be input by the user, for instance in a similar manner to the manual location fix shown in Figure 14 and Figures 2-6.

In general, a network fix will not be available to provide a starting point for the destination manual location fix. However, in the case of a cellular communication system, the bounding area for the X-letter search algorithm may be restricted to features in the current cell and surrounding cells. In other examples the bounding area is based on the (already determined) starting location plus a reasonable walking distance; or on a broad area input by the user, for example a town or part of a city. Alternatively, the bounding area may be specified as the current location of another mobile device. In the latter example, if a medium or high accuracy location fix is available for the second mobile device, this may be used to fix the destination completely.

Once a bounding area has been defined, the identification of the exact destination follows the same procedure as already described for obtaining a manual location fix.

Alternatively, location tags, or their containers, can be stored as a list of 'MyPlaces' either on the mobile device 4 or on some mobile portal (not shown). Containers for location tags can be generated by a variety of applications (for example a web site generating web pages from information in a directory).

This might include fixed points such as his office or home, but becomes much more powerful when entries can be created from location information provided from another source. Examples of such sources include:

- A 3rd party such as a friend or colleague trying to provide information about where to meet – or a receptionist trying to provide 'last mile' directions over the phone to a visitor finding their way to an office
- A 'how to find us' section of a web site where the user wants to have the information available from his phone – rather than having to print a map
- A user preplanning a route using a web site specifically associated with the routing & guidance service or a general internet mapping site for the same application
- An extended output from a Directory Enquiries service which includes the location of the listing as well as the telephone number
- The location of a friend or relative who is happy for the subscriber to know where they are for defined periods

The addition of entries to a MyPlaces list is as simple as the execution of a simple script from a website that only requires the entry of the mobile number of the 'MyPlaces' owner for identification. This is sufficient to ensure that the location is added to the personal MyPlaces list for that user – held as a simple database within the wider service.

An example is shown in Figure 21.

In this example, a MyPlaces user is travelling to an appointment at a city centre office he is unfamiliar with. He parks his car at a public car park and then realises he doesn't know exactly how to get to his chosen destination.

1. He dials the office he is trying to reach and asks the receptionist to go to the MyPlaces web site.

2. She enters his mobile number into a form and then the address of the office.
3. The businessman accesses the MyPlaces service on his mobile, which now has the new MyPlaces location that has just been created set as the current target, and receives dynamically created step by step directions to the office.

If the person is familiar with the area (for example this is a Friday night meet 'in town') but cannot recollect the exact location of the destination then they can select the "Destination?" option to 'display' the location tag. The server 1 accepts the location tag and returns a location schematic, which indicates the target location in the context of well-known landmarks, as described in detail below.

The location schematic is used to describe where something is to a person who is familiar with the area. In some cases this is merely a matter of 'jogging their memory' (for example 'the Tram Depot' is the pub just off East Rd.).

The purpose of the location schematic is to provide a person with a general idea of where either they, or some other location, are situated by reference to major features or landmarks in the vicinity. The aim is to choose landmarks that the person may be familiar with. It is not necessary that the landmarks actually be visible from the place. However it is necessary that there are sufficient landmarks shown to give an approximate idea of where the destination is. One of the aims is to avoid needing to provide the user with more detailed instructions on how to reach the destination.

The location schematic is generated by searching within a pre-defined radius of the destination for network elements (for example roads and paths) as well as POIs. The method of selecting POIs is described below under the heading "Location Schematic POI selection".

Routes are generated between the selected POIs and the target location. The cost of traversing network elements is weighted to favour major roads and paths. If any of these routes has a length greater than a threshold value, the POI is removed and an alternative sought. The extents (expressed as Minimum Bounding Rectangles) of the routes, POIs and destination are combined to provide a total extent for the schematic. A simplified graphical view is generated that includes the destination, POIs and some of the network. The network elements used in the routes are formed up into Paths (as for the orientation schematic). The Paths displayed ensure that Paths become more significant (based on the classification inherent in the network data) as they move away from the destination. Thus minor roads connecting POI to a major road that then leads to the destination are not displayed.

Alternatively, a textual version may be produced that describes the destination as being near the POIs and, optionally, as lying along particular roads.

If the person is unfamiliar with the area (for example arriving from 'out of town') then, if they have already identified their present location, they can select the "Directions" option from the menu of Figure 1.

Directions

Once the current location and desired destination of the device have been identified with sufficient accuracy, the system is able to direct the user from one to the other. Also, instead of identifying the device's current location, the user may specify a different starting location. The user may, for example, wish to plan a later journey with a starting point different to his current location. This can be achieved using the same procedure as described for the identification of the destination.

In the present example, once a starting and destination location have been specified, the user may select the "Directions" option on the menu screen (Figure 1) in order to obtain routing information.

The nature and generation of the routing information will now be described. First, the nature of the routing information generated by the system will be described with reference to Figures 7 to 12. Then, the method of generating said information will be described.

The routing information provides information describing the route from the selected starting location to the desired destination and can comprise graphical and textual information. As the information is generated for use on a mobile device, which is usually fairly small, the information is typically arranged in segments (referred to hereinafter as "routing schematics") providing detailed information on first and subsequent sections of the route.

Optionally, an overview of the entire route may be presented before the first routing schematic. The overview provides a summary of the requested route. Figure 7 gives an example of such an overview generated for a small screen, containing only text and showing distance and walking time. From here the user may proceed to obtain more detailed routing information, in this example by clicking on the icon consisting of a circle and an arrow, which causes a route update request to be sent to the server. The server then generates and transmits to the mobile device the information for the first segment of the route.

Where a large enough screen is available, the summary also includes a graphical overview of the route, as illustrated in Figure 10.

The user is then led through the route via a series of routing schematics. These schematics may be generated on request from the user (for example by selecting a 'next route segment' option or clicking on an appropriate icon), or may be

generated in some intelligent way: for example by carrying out regular network fixes to monitor the current location of the user and updating the routing schematic in response to changes in the current location. These regular network fixes may be assisted by the knowledge of where the user has been previously on the route.

In the following examples, it is assumed that the user manually steps through the sequence of schematics without the assistance of further network location fixes.

For devices with small screens, the routing schematics are:

- *Junction schematics:* at junctions, a detailed schematic of each junction, along with arrows to indicate movement through the junction and points of interest to help the user work out where he is.
- *Non-junction schematics*: between junctions, a schematic of simplified road layout and key points of interest. The user steps through these displays manually as he progresses down the route. In some devices (described below under the heading 'Node Imager Display') the non-junction schematics may be omitted, and only junction schematics displayed.

Figures 8 and 9 are examples of routing schematics shown on a small screen. Figure 8 is a junction schematic and Figure 9 is a non-junction schematic. The routing schematics include outlines of buildings and roads, and names or numbers of buildings. Arrows show the route the user should take through the junction. Specifically, as can be seen in Figure 8, a first arrow shows the route to be taken into the junction, and a second arrow shows the route to be taken out of the junction.

Text directions for that segment are also shown, along with distance and time remaining. In these examples, interface icons are provided for zooming in and out (-, +), and for moving to the previous or next route schematic (<-, ->), and an up arrow icon is provided for returning to the menu of Figure 1. As previously stated, the actual user interface depends on the nature of the device.

For example, in Figure 8 the schematic includes a textual description of the route segment (the number in square brackets in this example is the segment number): "Directions: [3] turn left out of 'Fen Causeway' onto 'Trumpington Rd'. 1281m to target - 15 mins"; and a graphical representation of the junction between Fen Causeway and Trumpington Rd. A feature visible from the junction ("Royal Camb Hotel") is also labelled by way of a box of text superimposed onto the graphic. It should be noted that the box of text does not obscure any important information in the graphic.

For devices with medium screens, the routing schematics are:

- Consecutive schematics of sections of the route. The user steps through these as he progresses down the route.
- Each display covers multiple junctions, with routes indicated through and between each.
- Selected points of interest (landmarks, buildings, street furniture) around and between junctions are displayed.
- Most detail is displayed at the junctions. The number of junctions is generally two, but may vary.

Figures 11 and 12 are examples of route schematics as shown on a large screen. Unlike the small screen equivalents of Figures 8 and 9, here more than one junction is typically shown per screen. Features include street names, building names/numbers, road stubs at junctions etc. Arrows and dotted lines show the suggested route. Remaining distance and time are also shown. During daylight

hours, an icon of the sun could also be displayed, showing the position of the sun in the sky – this helps the user work out which way he is currently facing. A moon icon may be displayed at night.

Referring by way of example to Figure 11, at a first junction, Lensfield Rd is labelled by a text box. At that junction, two roads meet Lensfield Rd from the right, and one road meets Lensfield Rd from the left. These roads are not labelled. A route arrow leads the user through this junction, staying on Lensfield Rd. At a second junction, Lensfield Rd terminates and continues as Gonville Pl. At the junction between Lensfield Rd and Gonville Pl, two other roads (not labelled) join from the left and right. Three features visible from this junction are labelled: namely a Lloyds TSB Bank on the left, and numbers 1 and 2 Gonville Pl on the right. Two other houses in Gonville Pl which are not visible from the junction are illustrated in Figure 11, but not labelled. This keeps the amount of information down to a minimum.

The generation of routing schematics for a large screen device will now be described in detail below.

Step #1: Finding the desired route

The database provides road information as a network of interconnected nodes, where edges represent road segments and nodes represent junctions where road segments meet. As well as representing roads, the edges may also represent footpaths or any other entities accessible to pedestrians. The desired route is found by identifying a path of connected nodes through the network from the starting location to the finish location.

The route selected may be the shortest route, either in terms of distance or journey time. Where the routing information is aimed at a pedestrian user whose speed is taken to be roughly constant regardless of the type of road (or footpath)

used, the shortest distance and shortest travel time paths are likely to be the same. Therefore, given that distance information is readily available from the database, the shortest path in terms is calculated in terms of distance.

This is achieved using conventional path finding algorithms. For example, from the starting point, the software explores all possible edges to get to the next node on each edge. It stores each of these as a possible partial route. As each new node reached, it explores all possible edges to new nodes, and again stores each as a set of possible partial routes. It does this until the destination is reached. In an enhanced, more efficient version, each possible partial route is assigned an estimated total cost (e.g. current distance, plus the straight line distance to the target from the current end of the route). At any stage, only the partial route with the lowest estimated total cost is explored. Once one route has reached the destination, only partial routes with estimated costs lower than the actual cost of that route are explored further. This results in a faster determination of the lowest cost route. The exact mechanism for estimating the total minimum cost of a route may vary if a cost other than simple distance is required.

Alternatively, the route selection may be based on a user profile stored centrally after registration (for example in a memory coupled to the server 1), or stored on the device 4. For instance the user profile may specify that the route selection routine should seek to identify the safest route.

Finally, the user may be able to select a particular route, either during step#1 (ie before routing schematics have been generated) or during the course of the routing sequence.

Step#2 Building network structure around route

After a route has been defined in step#1, a data set containing extra network structure is built around this route.

Consider the route through a network shown in Figure 18.

The route itself is labelled 'A', roads labelled 'B' are major roads, other roads are minor roads. This type of classification is usually present in cartographical data (standard data from TeleAtlas may be used, or similar datasets are also available from NavTech and Ordnance Survey).

Starting from the route 'A', a data set of extra network structure is 'grown' out from the route a set distance (currently 80m). The growing algorithm follows those roads which are of equal or greater importance to the original route and adds portions of them to the data set, classifying them as 'route structure'. Roads which are of lesser importance are added to the data set as 'spurs' (road stubs). If a complete road is included as 'route structure' but is less than the set distance, then the roads that it connects with are also analysed.

Junctions where the original route meets a road of equal or greater importance are classified as 'significant'. Other junctions ('insignificant' junctions) would typically correspond to spurs.

The data set resulting from the growing algorithm on the example network is shown in Figure 19.

Those elements corresponding to the original route are labelled 'A', those labelled as 'route structure' 'B'. Elements labelled 'C' are 'spurs'. Significant junctions are marked with circles.

Step #3: Identifying points of interest (POIs)

Once the route has been calculated, points of interest (POIs) such as prominent buildings are identified along the route for later display to the user. These help the user find his way along the suggested route.

POIs near junctions are given particular importance as they can be referred to by the user when deciding which of several roads to take. To identify such POIs, a set of 'sectors' is constructed around each junction. An example of this is given in Figure 15 and 16.

The route passes along network elements 20,21 and 23. The junction comprising network elements 21-24 is divided into four sectors, each sector being bounded on two sides by an adjacent pair of roads and on the third side by a curved search radius 30-33 at a predetermined distance from the junction.

Each sector is assigned a sector ranking (a value between zero and one), giving preference to sectors that are adjacent to the route. Thus, in Figure 16, sector 30 is bounded on two sides by network elements forming part of the route and therefore has a high ranking; sectors 31 and 33 are bounded on one side only and therefore have a medium ranking; and sector 32 is not bounded on any side and therefore has a low ranking.

Each sector 30-33 is then searched for POIs and a ranking determined for the POIs found. A POI is a candidate if its geometry is contained by, or intersects with, the sector. The server 1 may search for POIs from a number of different data sources 50. For instance, one of the data sources 50 may be the Ordnance Survey dataset known as MasterMap, which includes objects with a Polygon geometry property representing Buildings. Another data source 50 may be the Ordinance Survey dataset known as AddressPoint that includes objects with a Point geometry property as well as address information for all postal

destinations in the UK. The AddressPoint Points lie inside the MasterMap Polygons, and can be used to give an address to a building. Another data source 50 may be the dataset provided by E-Street, which provides information on businesses, represented as single points with coordinates.

In general, the geometry of a POI may be represented by a Point, Polyline or Polygon. In some circumstances the POI may only have a Polygon geometry property. In such circumstances, a spatial search is carried out within the POI geometry to locate POIContent objects. The properties of these objects are then used as 'additional' properties of the POI. For instance, a large building (such as a hospital) may be represented by a large polygon in the MasterMap dataset. This polygon may partially overlap with one of the sectors 30-33 - for instance only a corner of the building may be within a sector and the rest of the building is outside the sector. Therefore the building itself will be identified as a POI within the applicable sector. A POI within the building, for instance contained in the AddressPoint or E-Street dataset (referred to above as a POIContent object) may fall outside the sector. Therefore the algorithm searches the entire building for POIContent objects and treats them as 'additional' properties of the building.

The POIContent objects are not generally treated as POIs. This avoids the possibility of confusion between the POIs (in this case, the building outline polygons) and the objects spatially located within them that carry the other information about the POIs.

In one embodiment, POIContent objects are ignored when searching for POIs – they will only be reached, if needed, via the POIs. In another embodiment, however, POIContent objects not contained by a building (or similar polygon) are treated in their own right as POIs.

The system addresses various problems associated with merging data from different data sources. These problems largely relate to the data being held in different formats, or data from different sources having different names/identifiers for identifying features (or properties of features) of the same type. This is tackled by having a common interface to all 'connectors' used to access data. The implementation of these connectors can thus present different data through a common interface. An object oriented data model is built on top of this interface.

More specifically, one of the problems is the problem of duplication of data. For instance the E-Street dataset may include a building name whose coordinates fall within a MasterMap polygon (for instance a building). The AddressPoint dataset may also include the same building name but at a slightly different position within the building. The interface correlates the building names from the two different sources and identifies that they both relate to the same building, thus avoiding duplication.

The ranking of each POI is calculated by adding together a number of contributions:

p1*significanceFactor +
p2*onRouteFactor +
p3*labelFactor +
p4*distanceFactor +
p5*sectorRanking

The various factors have a range of zero to one inclusive, and the parameters (p1,p2,p3,p4,p5) are provided as input to the location algorithm.

The significanceFactor indicates how significant the POI based on what type of POI it is. For example a POI representing a 'Cinema' may be considered more

significant than a POI representing a 'House'. The mapping of POI type onto a significance band (typically no more than a dozen) is defined based on the types available. This mapping may be different depending on the user profile. For example Pubs may appear higher in the ranking for men than it does for women. In addition the significanceFactor includes a component that ranks larger POIs as more significant than smaller ones (this is applicable when the POI has a Polygon geometry). This is calculated using the function described below that takes the square-root of Polygon area as input and then divided by the number of bands. The square-root is used since this provides a better estimate of how much of the POI faces the street.

The onRouteFactor returns a value between zero and one depending on how close the POI is to being 'on route'. If the address for the POI indicates that it is on the route, then it is assumed to be on route. Otherwise the nearest distance to the POI from the route is calculated; if this is below a threshold then the POI is assumed to be on route.

The labelFactor returns a value between zero and one depending on how much space the POI will require to label it in an image.

The distanceFactor returns a value between zero and one depending on how far the POI is from the junction/position being identified. This makes use of the function described below. The distance supplied to the function is the nearest distance between the POI geometry and the junction/position being identified.

The calculation of these factors makes use of a function that maps a value x onto a value in the range zero to one. This has the form

$$1.0 / (1.0 + \exp((x - x0) / xk))$$

To select POIs used to identify the junction, the appropriate sector ranking is added to the POI rankings and all sectors are marked as 'in use'. To select a POI the highest ranked POI from the 'in use' sectors is selected. The POI is then removed from further consideration and the sector marked as 'not in use'. The process is repeated to select additional POIs. If all sectors are marked as 'not in use', then they are all marked as 'in use' again.

Sometimes it is necessary to select POIs on a route 'leg' rather than at a route 'junction'. This is normally carried out if a route leg is judged to be greater than a threshold length. One or more virtual 2-arm junctions are introduced on the leg. The position of these virtual junctions are chosen to ensure that the resulting legs are neither too long (i.e. within a percentage, typically 25%, of the threshold length), nor have too many spurs (typically no more than four). Where possible the virtual junction is added at an existing node in the network, otherwise it is introduced part-way along an edge.

Typical values for the constants used in the POI ranking are given below, although it should be noted that an important feature of the system is the ability to change these values easily to tune the system for different types of data (e.g. in different countries):

- p1 = 3.0
- p2 = 2.0
- p3 = 1.0
- p4 = 1.5
- p5 = 1.2
- x0 = 10.0 and xk = 10.0 for areas in significance
- x0 = 15.0 and xk = 15.0 for distance from junctions
- Label factor is 0.0 if label length is < 15, and 1.0 otherwise.

Step #4: geometrical simplification of route

Once a suitable route has been found, the route structure is geometrically simplified as described above in reference to the orientation schematic and in Figure 16.

For the purpose of geometrical simplification, 'Paths' are condensed from those elements not labelled as spurs (for example, with reference to Figure 18, elements A and B). The remaining spurs C are subsequently associated with their paths, described as a distance along the path and an angle to it.

Different methods of defining a distance 'd' are discussed above with reference to the geometrical simplification of an orientation schematic. In the case of a routing schematic, the distance 'd' may be based on the size of the whole route: for instance 'd' may be one tenth of the size of the whole route.

Step #5: Route segmentation

Once the route has been geometrically simplified in step #4, in step #5 the entire route is segmented into individually displayable sections.

This is achieved by identifying 'significant' junctions along the route. A significant junction can arise from a variety of 'significant' events. For example 'significant' events include the route changing from one road to another (as determined by the name of the road) or crossing a more important road. These 'significant' events most commonly occur at nodes in the network data. Much source network data contains information about the names and priorities of road segments (edges) in a network. In addition source data can include information about whether a road segment is part of a junction or a roundabout. Thus a node along the route which could be expressed as 'Turn left off road X onto road Y'

is significant, whereas 'Continue on road A past a turning on your left into road B' is probably not.

A significant junction may be represented by a node in the network data, or it may be 'extended' and represented by a sequence of edges in the network data. Extended significant junctions are identified by looking for nodes along the route which are determined to be significant and then including adjacent edges which satisfy one or both of the following:

(a) the edge is short and the nodes at BOTH ends are 'significant',
(b) the edge is classified as being 'part of a junction/roundabout…' in the source data.

The route is initially split up into 'route sections' by finding those sequences of segments between significant junctions. A route section will include the whole of the significant junctions (if extended) that bound it. Thus consecutive route sections will overlap at extended significant junctions. Consider a route consisting of three junctions; j1, j2 and j3. Junctions j1 and j3 are simple and j2 is extended. This leads to two route sections; 'j1 to end of j2' and 'start of j2 to j3'. These two route sections overlap because they both contain all of j2.

Complexity of the paths between significant junctions may necessitate further segmentation to improve clarity. Sections are further divided up in order to satisfy further criteria such as maximum number of spurs (insignificant junctions) in a section or maximum length of a section. This is done by recursive subdivision.

For example, the route may be split into three sections as shown in Figure 20.

User interaction may also affect segmentation, as follows. By default, a schematic 'leg view' would display one route section. The scale of the image

will be chosen to fit the route section plus some overlap with the previous and next route sections, and any POIs associated with that section.

Therefore a single route section would typically correspond to a 'leg view'. However, the user may interactively choose to switch between leg views and junction views as he or she progresses along the route. If they switch between a junction view of a junction internal to an existing route section (say they switched from a junction view of the two spurs inside the first section in the example), the system may adjust the route sectioning accordingly in order to show a leg view which begins at the current user position. This is simply one example of how user interaction may affect route sectioning.

Steps #1 to #5 are performed once at the start of a routing session when the routing request is first received. The following steps, from step #6 onwards, are performed on-the-fly when a route update is requested by the user, and are typically (depending on the number of route segments) performed repeatedly for each route segment.

Step #6: Routing Schematic generation

Each individual routing schematic (generated in response to a route update request received from the mobile device) is based upon a segment of the previously generated and geometrically simplified route, with which a number of POIs will have been associated in step #3.

The choice of POIs actually displayed in any given routing schematic is further refined, as described below, and various techniques are employed to improve the clarity of the image, including the following:

- POIs are offset sufficiently from the roads to make them distinguishable if necessary.

- POIs, other icons (such as arrows) and spurs are moved up and down their associated paths to improve clarity without invalidating the fundamental information conveyed (for example, by keeping their relative position to each other consistent). Broadly, the algorithm looks at the classification of a road, its size and whether it is a side road or a crossroads. Depending on the road's importance, it shows a stub or may show more geometry.

- If it is not possible to display all display items without introducing conflicts, items are removed according to a relevancy assessment which takes into account their proximity to the user and any scoring statistics calculated during their original construction (see POI ratings above).

- Path lengths or relative angles or even path segmentation may be adjusted in order to further optimise the clarity of the resulting image.

More detail may be included in the first routing schematic to aid the user in correctly identifying their location with reference to the schematic.

Step #7: Schematic labelling

Once a schematic has been assembled, the image is labelled. The number of features that are labelled is limited depending on the available screen space. For each label, a discrete set of possible locations for the label is calculated by taking possible points on the geometry of the item being labelled, with a minimum and maximum separation, and then calculating label positions above, below, left and right of each point at a range of distances.

For each possible location, the labelling algorithm also generally calculates separate single and multi-line 'positions'.

A 'cost' for each of these positions is calculated, involving proximity of the label to the item being labelled, conflicts of the label with other display items, degree of overlap with other items, conflict with other labels (and their leaders) etc. Priorities are assigned to display items which should be avoided (e.g. a road that forms part of the route has high priority, whereas a side road has lower priority) and to items to be labelled (the next road that the user has to turn into has high priority, whereas a side road half way along a segment has low priority; large POI buildings near junctions have high priority, small ones have lower priority). No possible position is discounted at this stage, although a high cost may be associated with it if many conflicts are found.

The optimal configuration for all labels is sought by considering the solution space of all combinations of all the label positions. Given a potential solution (a configuration of all labels, each in one of their possible locations), the solution is ranked by assessing the cost of each label position, and the conflicts of the labels in that position with each other. This is a classic optimisation problem which may be solved by exhaustive searching, simulated annealing or other appropriate known methods.

Step #8: Additional information

Finally, other information may be placed on the screen to further aid the user. In the present example this includes the current position of the sun, moon or shadows (depending on the current time of day and weather conditions), to allow the user to determine his current orientation relative to the schematic displayed on the mobile device.

An example of a sun icon is shown in Figure 22, where a sun icon is displayed slightly to the left and below the label reading "Ymca". This feature could conceivably also be used on a small screen.

A method of indicating the direction of shadows is shown in Figure 23. A depiction of the sun is fixed in a corner of the screen but shaded according to the direction shadows will be thrown. Alternative versions of the software could display shadows thrown by the actual items in the map.

Some mobile devices also include compasses, which may be used to align the schematic on the screen or to provide an indication of the user's current direction.

The completed routing schematic may, depending on requirements, be augmented with text descriptions, as exemplified in Figures 8 and 9, including directions expressed as text and the distance and journey time remaining.

Node Imager Display

The operation of a node-imager display device will now be described with reference to Figures 8 and 9.

A node-imager display is used to provide a junction-by-junction "bird's-eye" view of a route. The node-imager display only provides junction schematics (such as Figure 8) and omits all non-junction schematics (such as Figure 9). Showing the route junction-by-junction is more suitable for small devices where display of the 'legs' of a route between junctions is impractical. The display from a node-imager also differs from a schematic (of the type described above in step#1 to step#8) in that it provides more detail of the junction and does not alter (ie simplify) geometry. This provides enough detail to allow the user to be reassured that they are dealing with the correct junction.

The input to a node-imager display is a simple route, being a sequence of connected edges through a network of nodes and edges.

The route is first processed to identify the junctions along the route. These computations are performed once when the route is determined.

The algorithm analyses each node and identifies which nodes are 'junction' nodes. A node is classified as a 'junction' node if that node represents a significant instruction (for example 'turn left off road X onto road Y'). If the node represents a less significant instruction (for example 'continue on Road A past a turning on your left into Road B') then the node is not identified as a 'junction' node. A similar process is performed to identify 'junction' edges. This is determined by (a) whether the edge is short and the nodes at each end are themselves significant or (b) the underlying data classifies this edge as being part of a junction.

"Points of interest" (POIs) are sought within a specified search radius at the junctions along this route, using the method described above in step#3.

Once the 'junction' nodes and edges have been identified as described above, the route is segmented into junctions. The subsequent computations involve determining the display area associated with each junction for usability and clarity on a small device, and how best to display the information associated with each junction in a small device image.

The area to be displayed for each junction is calculated as follows:

- the map is rotated so that the user arrives from the bottom (for portrait devices) and from the left (for landscape devices). For the initial image the map is rotated so the user leaves via the top (portrait) or via the right (landscape).

- the minimum bounding rectangle (MBR), in this rotated space, is determined for that part of the route that begins a specified distance along the route before the junction, the interior of the junction and a specified distance along the route after the junction.

- the MBR is extended to include those parts of the selected POIs which fall within the search radius of the junction (so that only part of the building outline may be shown).

- a scale and centre for the final image is chosen to maximise the scale at which the image can be displayed subject to showing the entire MBR.

The images are generated on the fly on a per-junction basis. These are generated by displaying the polygons associated with key features at the junction, specifically the roads and buildings. These polygons are what provides the necessary detail. Features that represent POI are highlighted and labelled. Labelling of the image is undertaken as a final stage in the same manner as described above for a schematic. The route is represented by an incoming arrow on a section of route before the junction and an outgoing arrow on a section of route after the junction. Thus these arrows are unambiguously associated with edges which are not part of the junction itself. This approach does not attempt to dictate to the user how to negotiate the junction, rather it leaves these details to the user 'on-the-street' where additional constraints may be visible.

Instead of presenting the user with a graphic schematic as described above in steps #7 and #8, the device may present information in the form of text only, and/or as a synthesised voice.

If a user becomes lost or disorientated, then the options available will depend on whether a network fix is available.

If no network fix is available, or only a low accuracy network fix is available, then a new manual location fix must be carried out, as described above.

If a medium accuracy fix is available, then this can be used the starting point of an orientation step, as described above.

If a high accuracy network fix is available, then no orientation step may be necessary.

Orientation Schematic POI selection

POIs are identified for the junctions using a modified form of the POI location described below under the heading 'Directions". In this case the 'onRouteFactor' and 'sectorRanking' are always set to zero. Additional sectors are constructed for any Polygons entirely bounded by paths between identified junctions.

Location Schematic POI selection

POIs are selected for a location schematic based on their significanceFactor, as used by the ROUTING SCHEMATIC described below under the "Direction" heading. Note that other elements of the POI ranking are ignored. The area of the schematic will be chosen to include at least two and ideally more POIs.

Customisation

As mentioned above, the route selection and generation of schematics may vary depending on user profile, screen size etc. In addition, this may vary depending on the profile of the LBS. For instance the LBS may be a specialist service providing directions to pubs. In this case, the POI selection parameters are weighted so as to select pubs in preference to other POIs.

Data Sources

All the data used by the system is commercially available. There are numerous alternative sources of data in the UK, and equivalents (with different degrees of comprehensiveness and accuracy) in other countries. For example, the following different classes of data may be used for the UK:

- Large scale cartographic data (for example Ordnance Survey MasterMap), including building outlines (used in POI calculations, and may be used to locate things like rivers and parkland to be represented on the schematics). The junction view (see above) can be represented using schematics, or can be showed by displaying a small but accurately drawn extract from the cartographic data covering the junction of interest (i.e. a small map), with the outlines of POI buildings highlighted and labelled. Whether this view is presented, or the schematic view, may depend on how the system is configured, may be user configurable or may be dependent on the device.
- Road network data (for example TeleAtlas), which includes connections between roads (e.g. at junctions), absence of connections between roads that cross but do not connect (e.g. flyovers), classification of roads (Motorway, A, B etc), some pedestrian paths/walkways, identification of separate road geometries that make up the same complex road layout (e.g. junctions, roundabouts, dual carriageways). Similar data is also available from NavTech and Ordnance Survey.
- POI data (for example E-street and Ordnance Survey AddressPoint), that consists of points with attributes and classifications identifying the nature and specific details of potentially interesting things in the real world (shops, restaurants, landmarks etc). The AddressPoint data has a point for every address in the country, but includes only 'vanilla' information like name (in some cases, particularly businesses), number and postcode. The E-street data identifies a smaller number of points,

but with much better classification and information about what and who they represent. POI data is used in the POI location step. There are other suppliers.

Further preferred features of the invention are described below in Annex A.

It will be understood that the present invention has been described above purely by way of example, and modifications of detail can be made within the scope of the invention.

Each feature disclosed in the description, and (where appropriate) the claims and drawings may be provided independently or in any appropriate combination.

Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

CLAIMS

1. A method of providing a graphical schematic of a location, the method comprising the steps of:
   a) selecting one or more of points of interest from a database in accordance with a predetermined selection algorithm;
   b) generating a graphical schematic including the selected points of interest; and
   c) outputting the graphical schematic generated in step b).

2. A method according to claim 1 wherein the algorithm includes the steps of:
   a) ranking a plurality of points of interest; and
   b) selecting one or more of the points of interest in accordance with their rank.

3. A method according to claim 1 or 2 wherein the algorithm includes the steps of:
   a) retrieving one or more stored parameters associated with each point of interest; and
   b) selecting one or more of the points of interest in accordance with their associated stored parameter(s).

4. A method according to claim 1, 2 or 3 wherein the selection algorithm comprises the steps of:
   a) selecting a location; and
   b) selecting one or more points of interest within a predetermined radius of the selected location.

5. A method according to any of the preceding claims wherein the database includes a plurality of nodes and the selection algorithm includes the step of:
   a) selecting a node;

b) defining a region surrounding the node; and

c) selecting points of interest within the defined region.

6. A method according to claim 5 wherein the step of defining a region surrounding the node comprises defining a circular region centred on the node.

7. A method according to any of the preceding claims further comprising the steps of:

a) calculating a direction; and

b) including information in the schematic which indicates the direction calculated in step a).

8. A method of providing a graphical schematic of a location, the method comprising the steps of:

a) calculating a direction;

b) generating a graphic schematic including information which indicates the direction calculated in step a); and

c) outputting the graphical route schematic.

9. A method according to claim 7 or 8 wherein the information comprises a marker.

10. A method according to claim 9 wherein the marker comprises an arrow.

11. A method according to any of the preceding claims further comprising the steps of:

a) determining the current position of the moon or sun; and

b) including information in the graphical schematic which indicates the current position of the moon or sun determined in step a).

12. A method of providing a graphical schematic of a location, the method comprising the steps of:

a) determining the current position of the moon or sun;

b) generating a graphical schematic of the location, the schematic including information which indicates the current position of the moon or sun determined in step a); and

c) outputting the schematic generated in step b).

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13. A method according to claim 11 or 12 wherein the information comprises a marker.

14. A method according to claim 13 wherein the position of the marker within the schematic is dependent on the current position of the moon or sun.

15. A method according to claim 13 or 14 wherein the marker comprises a shadow image, the configuration of the shadow image being dependent on the current position of the moon or sun.

16. A method according to any of the preceding claims further comprising the steps of:

a) receiving configuration data; and

b) generating the graphical schematic in accordance with the configuration data received in step a)

17. A method of providing graphical schematic data, the method comprising the steps of:

a) receiving configuration data;

b) generating a graphical schematic in accordance with the configuration data received in step a); and

c) outputting the graphical schematic generated in step b).

18. A method according to claim 16 or 17 wherein the schematic is output to a device, and wherein the configuration data is indicative of a property of the device.

19. A method according to claim 18 wherein the property is the screen resolution of the device.

20. A method according to any of claims 16 to 19 wherein the configuration data is indicative of a user preference.

21. A method according to any of the preceding claims further comprising the steps of:
   a) storing a list of location identifiers;
   b) selecting one of the stored location identifiers; and
   c) generating a graphical schematic associated with the selected location identifier.

22. A method of providing graphical schematic data, the method comprising the steps of:
   a) storing a list of location identifiers;
   b) selecting one of the stored location identifiers;
   c) generating a graphical schematic associated with the selected location identifier; and
   d) outputting the graphical schematic generated in step c).

23. A method according to claim 21 or 22 further comprising the step of updating the list of location identifiers.

24. A method according to claim 21, 22 or 23 wherein the graphical schematic is output to a device, and the method further comprises the steps of:
   a) receiving a selection request from the device; and

b) selecting the location identifier from the list in accordance with the selection request.

25. A method of providing graphical schematic data, the method comprising the steps of:

a) providing a first schematic, the first schematic comprising graphical data associated with a specified region; and

b) after step a), providing one or more one or more routing schematics, the routing schematic(s) indicating a route from a first location to a second location.

26. A method according to claim 24 or 25 wherein the first schematic is an orientation schematic and the specified region includes the first location.

27. A method according to claim 24 or 25 wherein the first schematic is a location schematic and the specified region includes the second location.

28. A method according to claim 24 or 25 wherein the first schematic is an overview schematic and the specified region includes both the first and second locations.

29. A method according to any of claims 24 to 28 wherein the first schematic and/or the routing schematic(s) are generated by a method according to any of claims 1 to 23.

30. A method according to any of the preceding claims wherein the graphical schematic includes first source data from a first source and second source data from a second source.

31. A method of providing a graphical schematic, the method comprising the steps of:

a) obtaining first source data from a first data source;

b) obtaining second source data from a second data source;

c) generating a graphical schematic including said first source data and said second source data; and

d) outputting said graphical schematic generated in step c).

32. A method according to claim 30 or 31 including the steps of:

a) identifying a first feature in the first data source;

b) identifying a second feature in the second data source;

c) determining whether the second feature overlaps with the first feature; and

d) associating the second feature with the first feature if the second feature overlaps with the first feature.

33. A method according to any of the preceding claims further comprising generating the schematic by modifying graphical data in accordance with a predetermined modification algorithm.

34. A method of providing a graphical schematic of a location, the method comprising the steps of:

a) retrieving graphical data from a database;

b) generating a schematic by modifying the graphical data in accordance with a predetermined modification algorithm; and

c) outputting the schematic generated in step b).

35. A method according to claim 33 or 34 wherein the modification algorithm aligns the graphical data with a selected screen geometry.

36. A method according to claim 33, 34 or 35 wherein the modification algorithm simplifies the graphical data.

37. A method according to any of the preceding claims comprising outputting a plurality of route schematics which together provide an ordered sequence of directions from a first location to a second location.

38. A method of providing route information, the method comprising outputting a plurality of route schematics which together provide an ordered sequence of directions from a first location to a second location.

39. A method according to claim 37 or 38, further comprising receiving a routing request including the first location and the second location.

40. A method according to claim 39 wherein the routing request is received from a user device; and the route schematics are transmitted to said user device.

41. A method according to any of claims 37 to 40 wherein the route schematics are output in sequential order.

42. A method according to any of claims 37 to 41 further comprising receiving one or more route update requests; wherein at least one of the route schematics is a route update schematic which is transmitted in response to a respective route update request.

43. A method according to claim 42 wherein each routing update request is received from a user device; and each route update schematic is transmitted to said user device.

44. A method according to claim 42 or 43 wherein each route update request is generated in response to a user input.

45. A method according to any of claims 37 to 44 further comprising the steps of:
    a) selecting a sequence of said nodes which define a route between the first location and the second location; and
    b) compiling a route schematic for each selected node.

46. A method according to any of the preceding claims further comprising performing a network fix to monitor the current location of a mobile device, wherein the or at least one of the schematics is transmitted in response to a change in the monitored location of the mobile device.

47. A method according to any of claims 37 to 46 wherein at least one of the route schematics comprises a summary schematic giving an overview of directions from the first location to the second location.

48. A method according to any of the preceding claims wherein the schematic is output to a hand-held device.

49. A method according to any of the preceding claims including determining the location of a device, the device including a user input device and a transmitter, the method comprising the steps of:
    a) receiving a location identifier from the user input device;
    b) transmitting the location identifier from the transmitter to a server;
    c) receiving the location identifier at the server; and
    d) determining the location of the device at least partially on the basis of the received location identifier.

50. A method of determining the location of a device, the device including a user input device and a transmitter, the method comprising the steps of:
    a) receiving a location identifier from the user input device;
    b) transmitting the location identifier from the transmitter to a server;

c) receiving the location identifier at the server; and

d) determining the location of the device at least partially on the basis of the received location identifier.

51. A method according to claim 49 or 50 wherein the device is a hand-held device.

52. A method according to claim 49, 50 or 51 further comprising the step of performing a network fix on the device, and determining the location of the device on the basis of the network fix and the received location identifier.

53. A method according to any of claims 49 to 52 further comprising the steps of:

a) transmitting a plurality of possible locations to the device;

b) presenting the possible locations to the user;

c) receiving a location selector from the user input device, the location selector identifying one of the possible locations;

d) transmitting the location selector from the transmitter to a server;

e) receiving the location selector at the server; and

f) determining the location of the device on the basis of the received location selector..

54. A method according to claim 53 wherein the location identifier comprises a sequence of one or more letters, and the method further comprises selecting a plurality of possible locations each including the sequence of one or more letters.

55. A method according to claim 53 or 54 wherein the location identifier comprises a location category, and the method further comprises selecting a plurality of possible locations each falling within the location category.

56. A method according to any of claims 53 to 55 wherein the possible locations are presented to the user in graphical form.

57. A method according to any of claims 53 to 56 wherein the possible locations are presented to the user in textual form.

58. A method of searching a database, the method comprising the steps of:
   a) searching the database to identify a number of database entries each including a sequence of X letters;
   b) determining whether the number of database entries identified in step a) exceeds a predetermined maximum;
   c) if the number of database entries identified in step a) is less than or equal to a predetermined maximum, then
      i) transmitting the value X to a user input device,
      ii) receiving a sequence of X letters from the user; and
      iii) searching the database to select one or more database entries each including the input sequence of X letters; and
   d) if the number of database entries identified in the step a) is greater than the predetermined maximum, then repeating steps a) and b) with a greater value for X.

59. A method of providing a schematic substantially as described herein with reference to any of the examples given in the accompanying drawings.

60. A method of providing route information substantially as described herein with reference to any of the examples given on the accompanying drawings.

61. Apparatus substantially as described herein with reference to Figure 13 or Figure 21 of the drawings.

62. Software architecture substantially as described herein with reference to Figure 17 of the drawings.

ABSTRACT

METHOD OF PROVIDING A GRAPHICAL SCHEMATIC OF A LOCATION, DETERMINING THE LOCATION OF A DEVICE, AND SEARCHING A DATABASE

Various methods of providing graphical schematics of a location are described. One or more of points of interest are selected from a database (2) in accordance with a predetermined selection algorithm. The schematics include information indicating a preferred direction, and may include information which indicates the current position of the moon or sun. The schematic is generated in accordance with received configuration data. The location to be displayed can be chosen from a list of stored location identifiers. The schematics can be used in a method of providing routing information from a first location to a second location. Methods of searching a database, and determining the location of a device (4) are also described.

m-spatial

Where are you? Red Bull

Destination? Six Bells

Directions

Figure 1

Where are you?

Specify by:

Bars,Pubs

Food Outlets

Shops

No. & Road Name

Road Junction

No. & Postcode

Figure 2

Where are you?

Specify by: **Bars,Pubs**

At least 3 letters

Go

Figure 3

Where are you?

Specify by: **Bars,Pubs**

Select from list:

- Green Dragon
- Green Man
- Greyhound

Or try more letters:

gre Go

Figure 4

Where are you?

Specify by: **Road Junction**

At least 3 letters of two Roads

eg. Sta Hil

Go

Figure 5

Where are you?

Specify by: **No.&Road Name**

At least 3 letters of Road

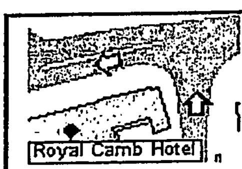
eg. 42 Hil

Go

Figure 6

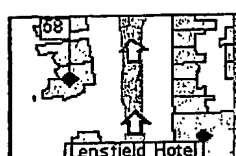
Distance of route 2313m. Approx 27 mins walk.

Figure 7



Directions: [3] turn left out of 'Fen Causeway' onto 'Trumpington Rd'. 1281m to target - 15 mins

Figure 8



Directions: [3] spur off 'Lensfield Rd'. 1101m to target - 13 mins

Figure 9

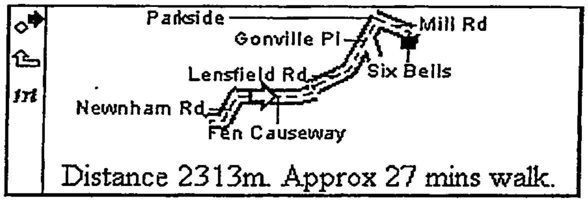


Figure 10

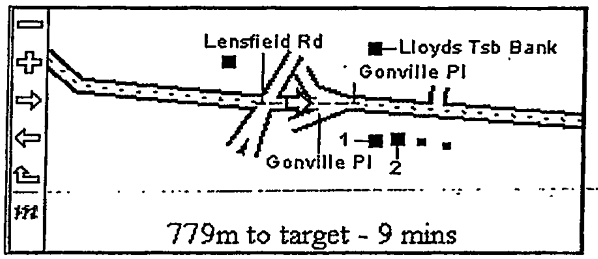


Figure 11

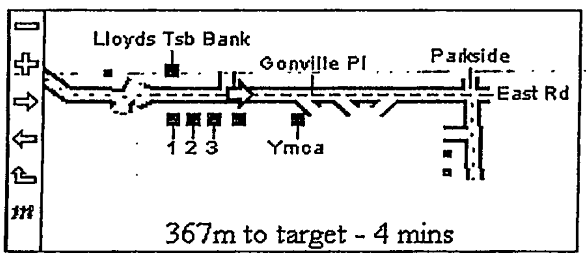


Figure 12

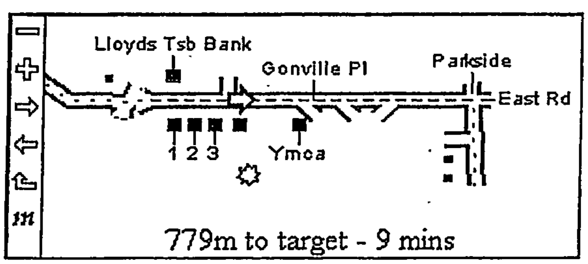


Figure 22

FIG. 13

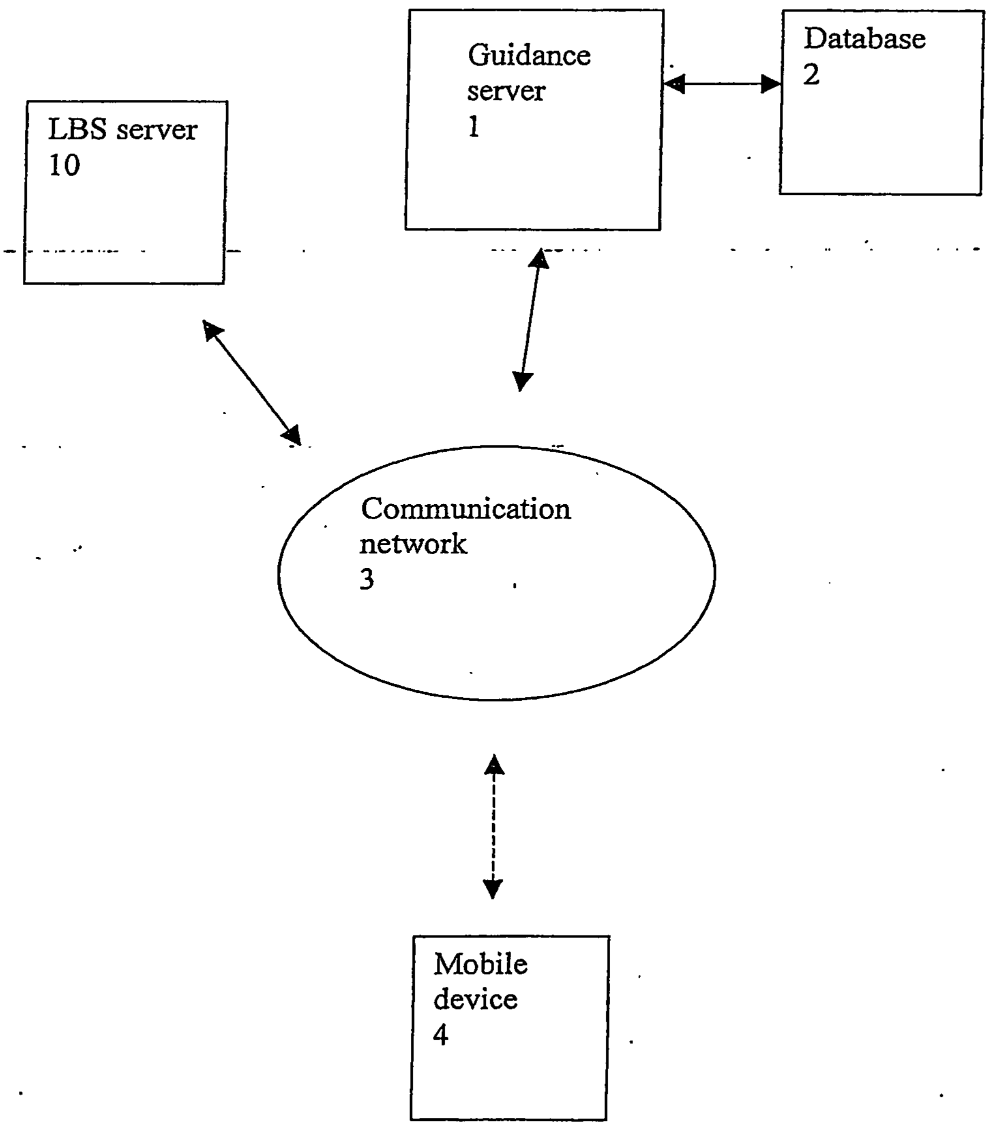
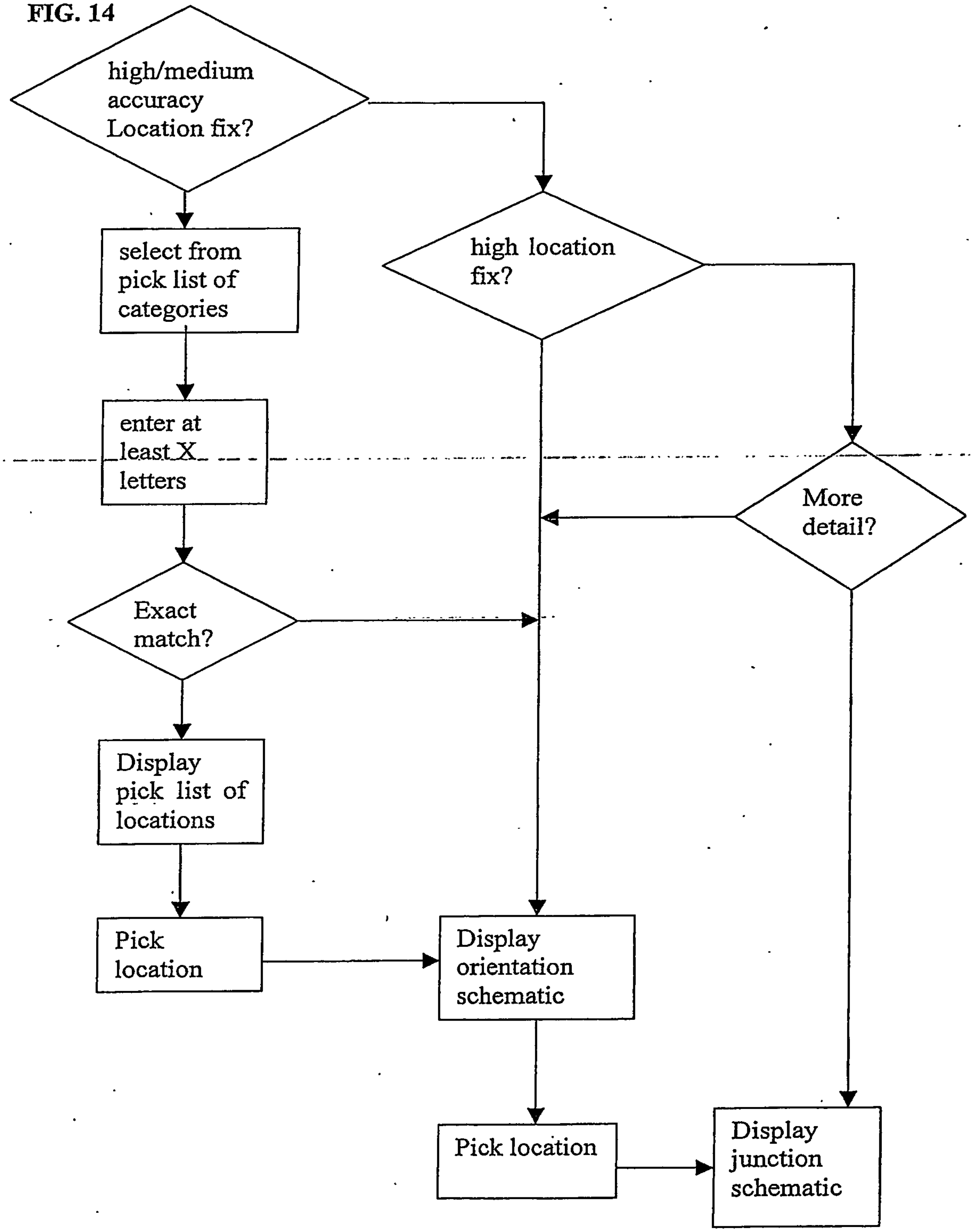

LBS server
10
Guidance
server
1
Database
2
Communication
network
3
Mobile
device
4

FIG. 14


high/medium accuracy Location fix?
select from pick list of categories
enter at least X letters
Exact match?
Display pick list of locations
Pick location
high location fix?
More detail?
Display orientation schematic
Pick location
Display junction schematic

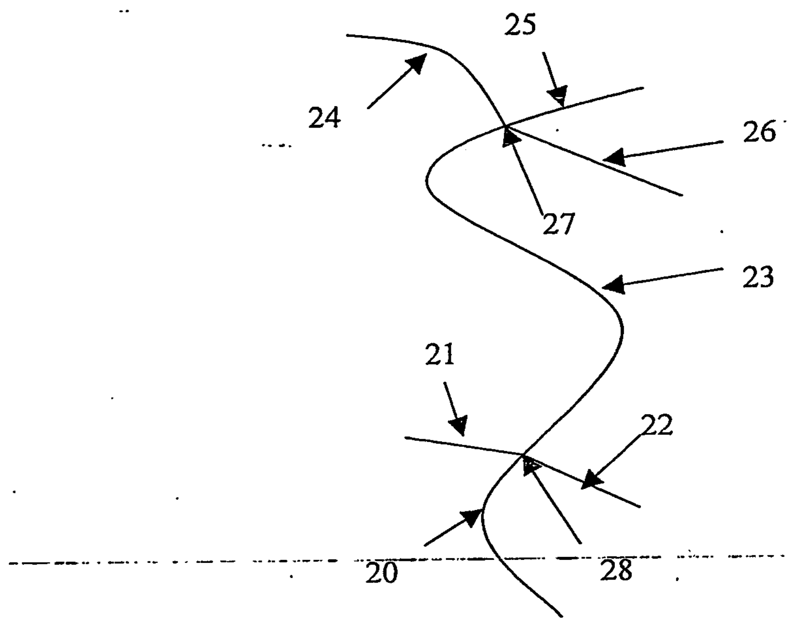


Fig. 15

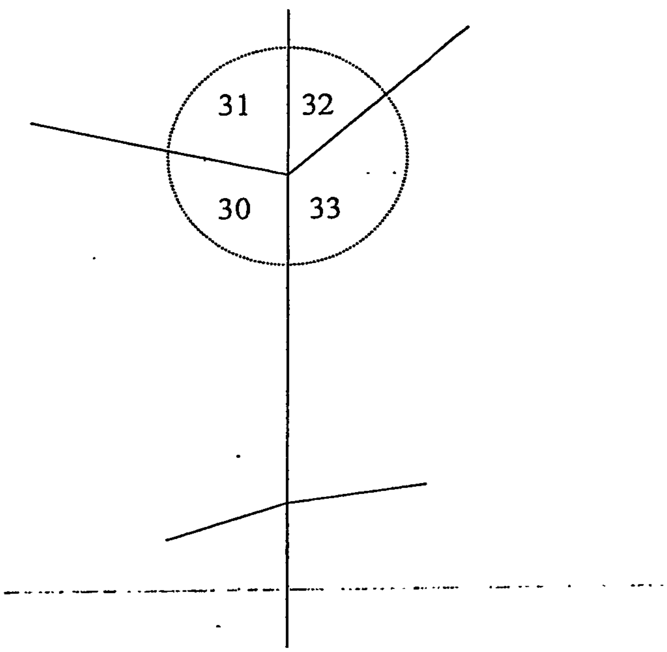


Fig. 16

FIG. 17

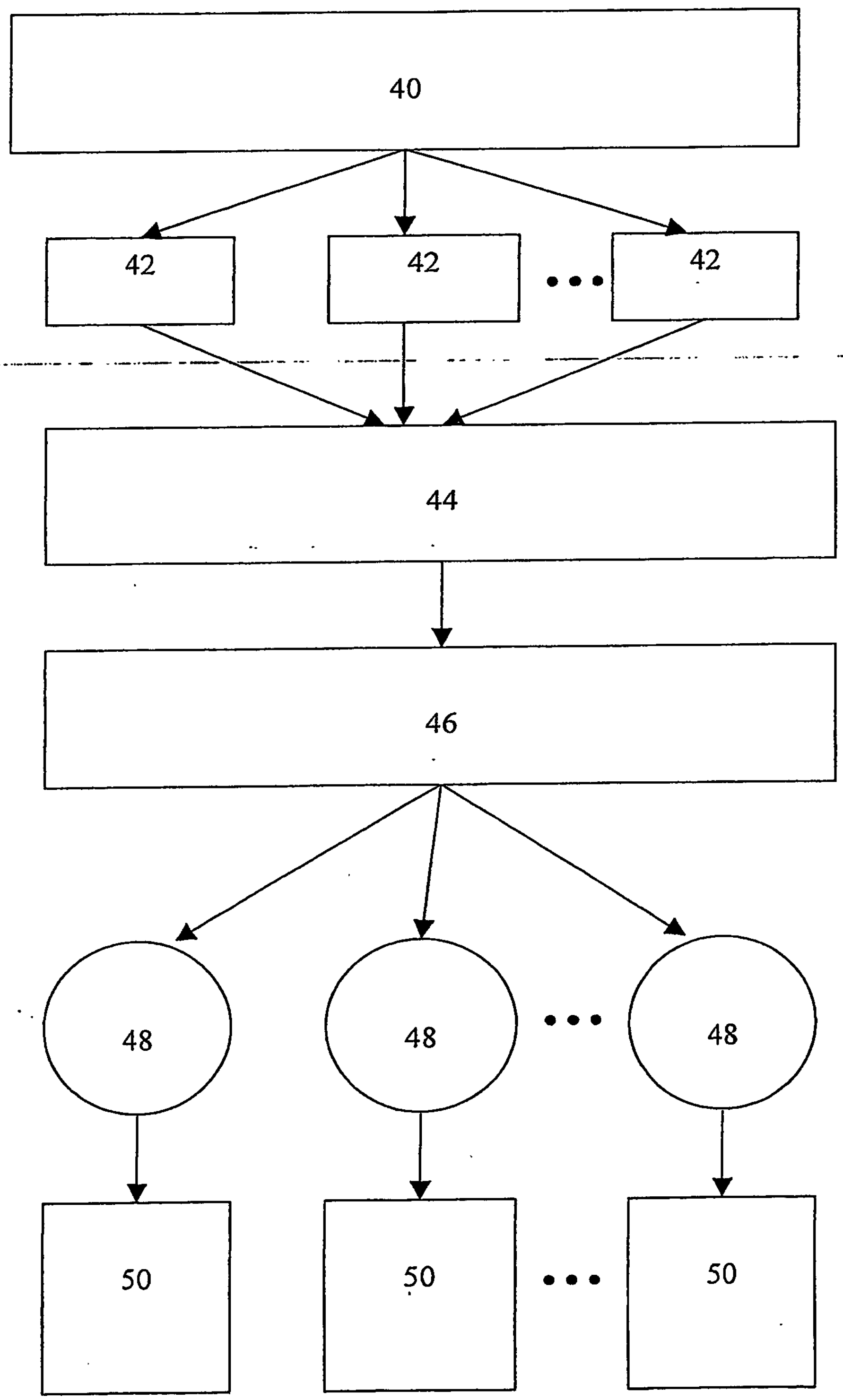


Fig. 18

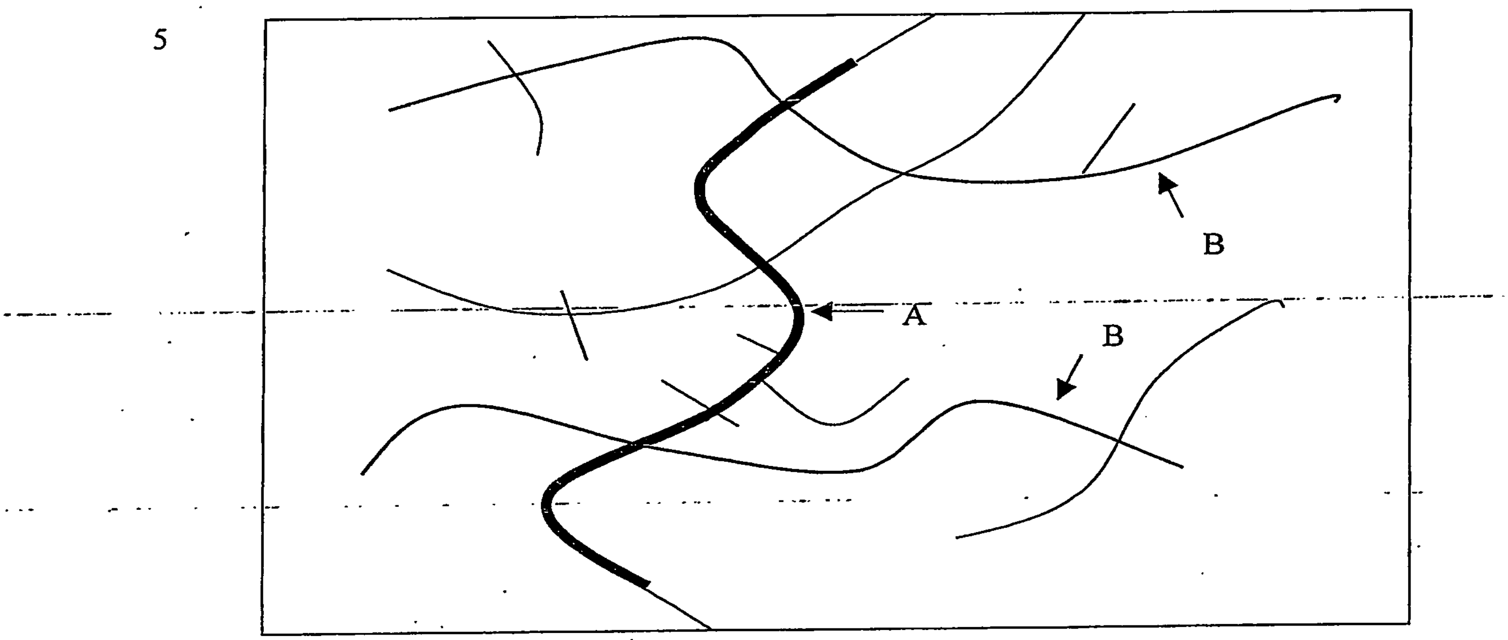


Fig. 19

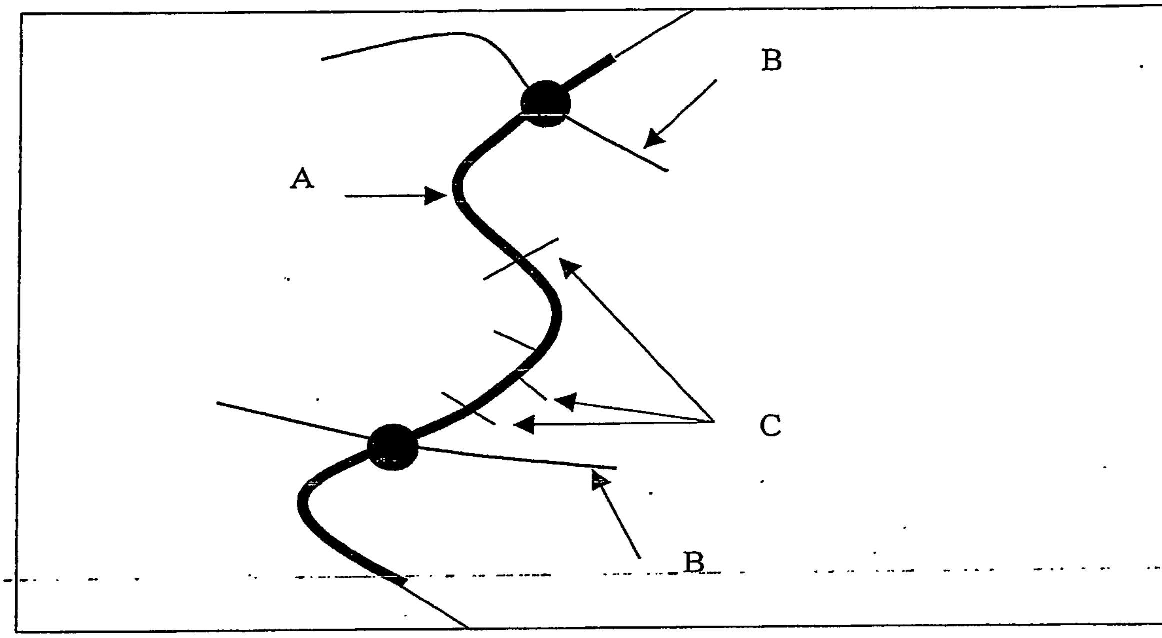
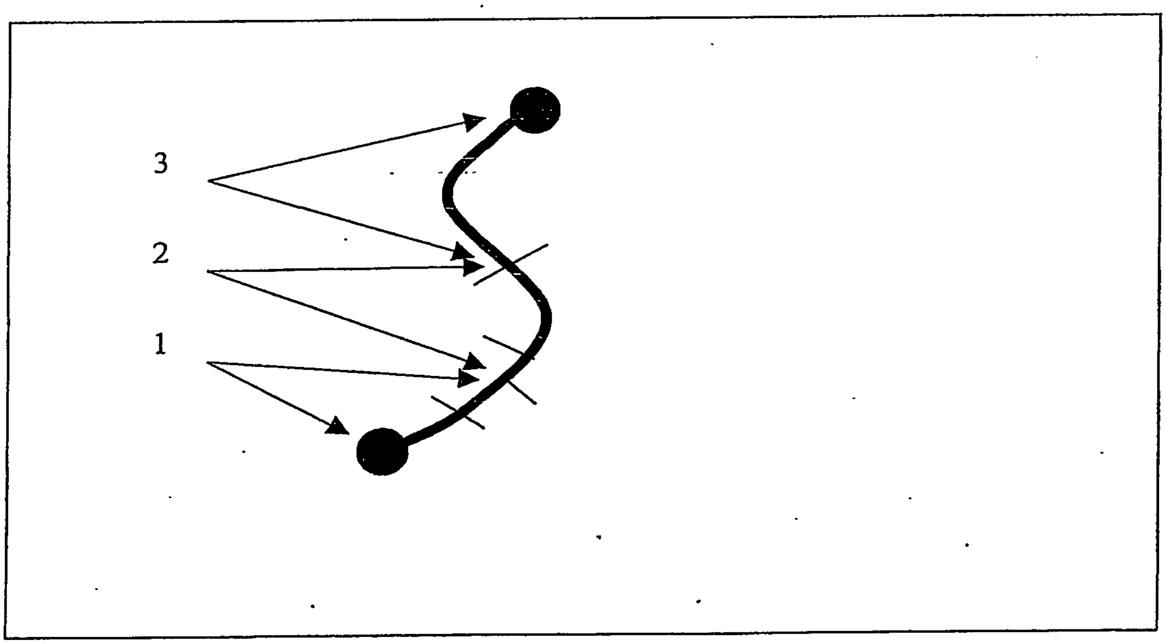


Fig. 20



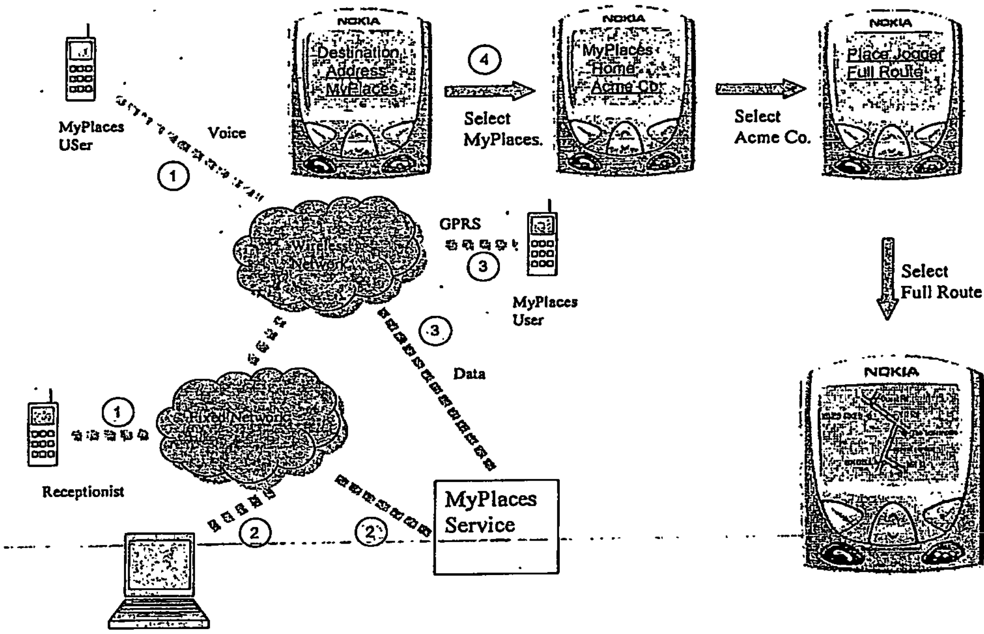

MyPlaces
USer
Voice
1
Destination
Address
MyPlaces
4
Select
MyPlaces.
MyPlaces
Home
Acme Co.
Select
Acme Co.
Place Jogger
Full Route
GPRS
3
MyPlaces
User
3
Data
Select
Full Route
1
Receptionist
2
2
MyPlaces
Service

Fig. 21

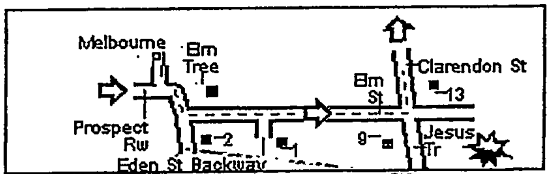

Melbourne Pl
Elm Tree
Prospect Rw
Eden St
Backway
Elm St
Clarendon St
13
2
1
9
Jesus Tr

Fig. 23